

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE 1994	3. REPORT TYPE AND DATES COVERED Final Report	
4. TITLE AND SUBTITLE Investigations of the Northern Caucasus to Determine the Extent and Magnitude of Crustal Motions Along a Section of the Eurasian - Arabian Plate Boundary			5. FUNDING NUMBERS F6170893W00941	
6. AUTHOR(S) Dr. Irina Kumkova				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) IAA RAS 8, Zdanovskaya Str. 197042 St. Petersburg, Russia			8. PERFORMING ORGANIZATION REPORT NUMBER SPC-93-4066	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) EOARD PSC 802 BOX 14 FPO 09499-0200			10. SPONSORING/MONITORING AGENCY REPORT NUMBER SPC-93-4066	
11. SUPPLEMENTARY NOTES				
12a. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution is unlimited.			12b. DISTRIBUTION CODE A	
13. ABSTRACT (Maximum 200 words) Investigation of the northern Caucasus to determine the extent and magnitude of crustal motions along a section of the Eurasian-Arabian plate boundary. <div style="text-align: right;">DTIC QUALITY INSPECTED 4</div>				
14. SUBJECT TERMS			15. NUMBER OF PAGES 25	
			16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT UNCLASSIFIED	18. SECURITY CLASSIFICATION OF THIS PAGE UNCLASSIFIED	19. SECURITY CLASSIFICATION OF ABSTRACT UNCLASSIFIED	20. LIMITATION OF ABSTRACT UL	

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102

SPC-93-4066

INVESTIGATIONS OF THE NORTHERN CAUCASUS TO
DETERMINE THE EXTENT AND MAGNITUDE OF
CRUSTAL MOTIONS ALONG A SECTION OF THE
EURASIAN - ARABIAN PLATE BOUNDARY

DR. IRINA KUMKOVA

IAA RAS,

8, ZDANOVSKAYA STR.

197042 ST.PETERSBURG

RUSSIA

19980512 066

I. INTRODUCTORY HISTORICAL-GEOLOGICAL REVIEW

The fold structure of the Greater Caucasus (GC) is the external part of the Alpine Fold Belt, bordering in the North with the Scythian epipaleozoic plate. The latter rims the ancient epi-Early Proterozoic East European platform. The Caucasian sector of the Alpine Fold belt in comparison to the neighboring sectors is sharply narrowed due to intensive movement northward of the Arabian Plate. The modern structure of the Caucasian sector was formed as a result of the mobile Tethys Belt and the collision between the Eurasian and Gondwana continents. The axial zone of the Alpine basin with the oceanic crust is located in the region of the Sevanic ophiolitic suture. The periphery of the Eurasian continent in the Alpine period was active and the periphery of Gondwana - passive. After the closure of the last basin with the crust of the oceanic type at the end of Late Cretaceous the collision process increased and reached the maximal stage. It started in the Late Miocene, when in connection with the opening of the Red Sea rift the Arabian Plate started moving northward at the rate of 4 cm per year. This process formed all modern structural elements of the Caucasian sector. As a result of the northward movement of the Transcaucasian micro continent an asymmetric mountain fold structure of the Great Caucasus was formed. It is characterized by a steep and narrow southern slope complicated by the thrust faults and nappes and also by wide and gentle northern slope. In front of the southern front of 6 intermountain basins, actually foredeeps, were formed while in front of the northern slope the basins formed in the Late Miocene are extremely rare. The Caucasus is the region of high seismicity, mainly of crustal type. Only in the region of the Terek-Caspian basin we have deep-focus earthquakes. The important factor in the seismicity distribution is oblique shearing zones, the most of which is Aghakhan-Tbilisi-Levantine left-lateral shearing zone, crossing the whole of the Alpine Belt, from the Caspian Sea to the grabens of Levant. The earthquakes are also connected with the sublatitudinal thrust faults. The zones of the transtension type also define the spreading of the Late Cenozoic collision volcanism.

Three Alpine folded mountain structures (meganticlinoria) are distinguished in the Caucasus segment of the Mediterranean belt - the Great Caucasus, the Lesser Caucasus and Eastern Taurus -Zagros structures. They are separated by zones of micro continents and intermountain arcs. From Young Scythian Plate in the north and the Arabian platform in the south the Alpine structures are separated by foredeep zones. In the middle part of the Caucasus segment all the longitudinal zones of the Mediterranean belt undergo positive undulation whose axis is marked as a submeridional zone of Transcaucasian transversal uplift.

Zone of the Caucasian foredeeps consists of two beaded deep asymmetric foredeep in the west and the Terek (Terek-Caspian) one in the east. They are separated by the transverse Mineral Waters saddle. The molasse Neogene-Quaternary complex reaches 5km and more in the foredeeps. It is absent in the Mineral Waters uplift. The subhorizontally bedding platform deposits of Cretaceous and Paleogene composing the uplift are intruded by series of laccolithic bodies of Late Miocene. The southern part of the deeper Terek foredeep is complicated by two longitudinal rootless anticlinal Pliocene zones marked in the relief - Terek zone and

Sunzha one. Thrusting of the adjacent folded structures over the foredeeps characteristic of most of them either is not observed in the Kuban and Terre foredeeps or is of slight and local development.

Meganticlinorium of the Great Caucasus appeared within the same side branch of the Alpine belt as the Mesozoic structure of the Mountain Crimea. However in the Caucasian side the branch was significantly wider and deeper. Its basins development was more complicated and prolonged, lasted till Cenozoic and was completed by formation of the largest folded structure. Both longitudinal and transverse zonation are clearly developed in the Great Caucasus structure. The former is manifested in the presence over the whole meganticlinorium of the most tectonically and orographically uplifted axial zone as a relatively gentle northern as well as and a steeper and intensely performed southern limb. The latter deformed into several segments differing in the width, absolute height of the relief and amplitude of neotectonic uplift, hypometric position of the Premesozoic basement top thickness of Mesocenozoic deposits, peculiarities of the tectonic structure of the Alpine complex etc. So there can be distinguished the most uplifted and widest central segment whose eastern part coincides with the axis of the Transcaucasian transverse uplift. The other part is the less uplifted but wide eastern segment and significant narrower and relatively lowered north-western and south-eastern segments, as well as zones of transverse subsidence separating the Great Caucasus meganticlinorium from structures of the Mountain Crimea and Kopet-Dag.

The northern limb of the Great Caucasus within the central segment, so-called Laba-Malka zone, is manifested in the Alpine complex structure as a gentle monocle composed of the Jurassic, Cretaceous and Paleocene-Eocene deposits. That corresponds to the southern part of the Scythian plate involved at the end of Cenozoic into the Major Caucasus structure uplift. However during the Hercynian cycle the main zone of the Mediterranean belt was within the Laba-Malka zone. The Riphean and Lower Paleozoic metamorphic formations and Middle Paleozoic volcanogenic-shale strata tectonically overlain by an allochthonous ophiolitic complex and deformed together with the latter during the Sudetian tectonic phase. During the orogenic stage of the Hercynian "cycle" this complex basement was partly buried under Late Paleozoic molasses filling several deep intermountain areas. During the Alpine "cycle" it was uncomfortably overlain by Jurassic-Paleogene platform cover.

In Jurassic time the northern boundary of the Great Caucasus Alpine basins passed along the very narrow Tyrnyauz suture zone now separating the Laba-Malka zone from the Great Caucasus axial part - anticlinorium of the Main range. The latter represents a thick rhombus-shaped uplift of the Premesozoic and partly Prepaleozoic metamorphic Caucasus basement which was gratified at the end of the Hercynian "cycle". At the end of the Alpine "cycle" the anticlinorium underwent intense up thrusting and now it forms a watershed zone of the Great Caucasus with the height of summits up to 4-5 km. In the eastern part of the Main range anticlinorium and in adjacent areas of the Laba - Malka and Tyrnyauz sutural zone there are centres of acid superficial Pliocene-Quaternary effusions and Pliocene granite intrusions of the Elbrus volcanic area located within the band of the Transcaucasian transverse uplift. The main

range anticlinorium is thrust southwards over intensively contorted Mesozoic deposits of the Great Caucasus Southern slope. The underlying Paleozoic (Silurian-Permian) and may be Triassic shale strata are exposed in the Svanetian anticlinorium. These deposits were accumulated in the Svanetian trough during the Hercynian time. From the south of the Great Caucasus structure is bounded by Cahetia-Lechkum sutural zone along which the structure was locally thrust southwards over the Transcaucasian intermountain area. In Mesozoic-Eocene this zone was a southern boundary of the Great Caucasus basin.

The eastern and other segments of the Great Caucasus meganticlinorium were formed inside the Early Alpine basin. Its axial zone is composed in them of thick shale strata with subordinate volcanic sheets as well as with sills and basic dikes contorted into strongly compressed isoclinal folds during the Later Cimmerian epoch (Preallovian phase). The northern limb is composed of epicontinental deposits of Jurassic, Cretaceous and partly Paleogene gathered in moderately compressed Neogene folds. The southern limb is composed of shale-volcanogenic strata of Lias and Dogger and of thick series of the Upper Jurassic, Cretaceous and Lower Paleogene flash contorted during Oligocene and Neogene into sternly compressed, reversed southwards folds.

As a whole the Great Caucasus anticlinorium appeared in the place of an early Alpine basin of the same name on the extended thinned continental crust penetrated by diabolic dikes. The axial zone of the basin underwent compression and inversion before Late Jurassic and thus separated local troughs and continued to subside till the Paleogene. Later the whole structure was subjected to a new strong compression and thrust over the Transcaucasian intermountain area and then underwent a rapid total upthrusting.

The Georgian and Azerbaijan microcontinent with the Prepaleozoic base are the basement of the Transcaucasian intermountain area separating the structures of the Great and Lesser Caucasus. These massives are overlain by covers of the Mesozoic sedimentary formation and by thick series of the Late Cenozoic molasses. The latter fill the small Rioni intermountain area in the west and the vast Kura area in the eastern part of the Transcaucasian zone. Becoming wider and deeper these areas "flow" into Black sea and South-Caspian depressions respectively. The Azerbaijan massive basement is very where below 8-10 km. The Georgian mass if basement in its eastern part is relatively elevated and ante small Dzirula uplift it even crops out. The upper Cenozoic molasses complex in the western and especially in the median part of the Kura intermountain area, where its thickness reaches 5-10 km, was contorted during the Pliocene-Quaternary age into asymmetric folds complicated by thrusts and with southwards mass displacement.

LITERATURE

1. Adamiaa Sh.A. et al., The Specific features of the tectonics of the Caucasus. M., Nauka, 1989, p.3-15
2. Baranov G.I., Grecoy I.I., Preupperpaleozoic structure of the Northern Caucasus.-The tectonics of the Mediterranean Belt. M., Nauka, 1980, p.162-171
3. Baranov G.I., The Problem of the geologocal structure of the Pre-middle-paleozoic basement of the Greater Caucasus., M., Nauka, 1987, p.106-111
4. Gamkelidze i.P., Adamia Sh. A., Knipper A.L., Overthrust tectonics of the Caucasian Sector of the Alpine Belt.- The burning issues of the tectonics of the USSR, M., Nauka, 1988, p.60-66
5. The Histiry of the ocean Tethys, M., The Institute of the Oceanology named after P.P.Shirshov AS USSR, 1987, 138pp.
6. Kopp M.L., The kinematics of the Caucasus at the orogenic stage.- The geodynamic of the Caucasus, M., Nauka, 1989, p.113-122
7. Lomidze M.G., The Alpine geosynclinal of the Caucasus in the global context.- Geotectonics, n2, 1987, p.14-23
8. Rastzvetaev L.M., The tectodynamic conditions of the Alpine structure of the greater Caucasus formation., M., Nauka, 1987, p.69-96
9. Rastzvetaev L.M., Shears and the Alpine geodynamics of the Caucasuan region.- The geodynamics of the Caucasus, M., Nauka, 1989, p 106-113
10. Rodojhin E.A., Shoplo V.N., The specific features of the inner structure of the full folding zone of the Greater Caucasus.- The geodynamics of the Caucasus., M., Nauka, 1989, p.15-28

INVESTIGATIONS OF THE NORTHERN CAUCASUS TO
DETERMINE THE EXTENT AND MAGNITUDE OF
CRUSTAL MOTIONS ALONG A SECTION OF THE
EURASIAN - ARABIAN PLATE BOUNDARY

DR. IRINA KUMKOVA
IAA RAS,
8, ZDANOVSKAYA STR.
197042 ST.PETERSBURG
RUSSIA

II. GEOPHYSICAL DATA REVIEW.

The Greater Caucasus is a orogenic construction of junction zone between Eurasian and Arabian lithospheric plates. Dynamics of the compression zone in Black Sea- Caucasian region is studied insufficiently, though a zone of Main Caucasian Thrust (Fig.1) is recognized by many researchers as a main plane of southward thrusting of northern geological block, correspondent to an ancient Benioff zone.

There is known only two discontinues cross-sections of the Greater Caucasus performed by Deep Seismic Sounding (DSS) in the beginning of 60-s. These are Bakuriani-Stepnoe profile and Volgograd- Nakhichevan profile (Fig. 1). In the same time seismic investigations by means of "Zemlya" equipment have been performed in the Krasnodar region. Registration of exchange waves from low amplitude earthquakes is a principle of the equipment.

From the middle of 80s the depth investigations have been started again along the network of profiles in the Elbrus- Mineral Waters region and along two profiles: along Teberda and Baksan rivers valleys. In this case seismic equipment "Tortilla" have been used. Later the profile across West-Kuban basin and Stavropol dome has been carried out. During the last decade the investigation of the Great Caucasus deep structure is started again. The work along Erevan-Tbilisi- Elista profile is carried out. The data of Armenian part of the profile crossing Spitak 1988 earthquake region is published and well known. The works are not finished in Georgia and also in the zone of the Greater Caucasus. Unfortunately there is not any cross section through the eastern part of the Greater Caucasus. Some researches are undertaken in the area of Makhachkala and Limestone Dagestan. To the south of Samur at Azerbaizhan territory it has been done a significant work for square and crossing.

The DSS data of existed profiles have been reconsidered by many researchers and also together with gravimagnetic data in framework of plate tectonics theory from the middle of 70-s. A

result of such an interpretation of Volgograd-Nakhichevan profile is presented on Fig.2. Necessary to mention that we will use the terms "granite" and "basalt" layers solely for convenience. In reality the transition between these layers is manifest according to bordering velocities indistinctly. Portions with lowered velocities of seismic waves and reduced rock density are distinct in the middle part ("basalt") of section. That is correspondent to "granite-basalt alternation" in accordance with physical characteristics.

Considering geological-geophysical section presents a typical subduction model. The crust thickens up 55-60 km beneath the Greater Caucasus due to "basalt" layer mainly. The location of the surfaces in section is accepted with taking into account of the density and velocity features fixed by reflection and refraction seismic border and discontinuities of the continuity. Observable picture can explain "basalt" layer thicken up. It is caused by thrust of the northern block to the southern one. A probability of real sink of "basalt" layer of southern plate into mantle is not excluded. That all are evidence of a typical subduction model.

The "granite" layer thickness is rather stable beneath the Greater Caucasus and Cis-Caucasus. But southward Terek river the "granite" layer is significantly destroyed according to variable velocities. The deep fault zone is conceived in Tsiteli-Tskaro area. It could be a junction zone of penetrating "granite" layer of the southern block, probably edge zone of ancient microcontinent, and "granite" layer of the northern block. The set of data upon Volgograd-Nakhichevan profile gives us assumption of displacement of exit to day surface of The Main Caucasian Thrust from mountain part of the Caucasus to Alasani river valley. In Kura depression Pre-Jurassic crystalline basement occurs here at the depth about 15 km and upper unconsolidated part of crust has imbricate structure.

One of the features of the Greater Caucasus deep-seated structure along Volgograd-Nakhichevan profile is supposition of zone of Cis-Caucasian deep-fault subparallel to subduction zone mentioned above. The modern thrust of the northern block is

manifested along this fault. Also the thrust could be connected with the origin of Terek-Sunzhen domes during Pliocene and Antropogene located in axial part of Terek-Caspian foredeep. They divide the foredeep on the several secondary depressions. The depth of fault is manifested by presence of deep focused earthquake centers in the fault zone.

Geological-geophysical section as results from DSS along the profile from Stepnce to Bakuriani crosses practically central part of the Greater Caucasus. The profile has been done in incomplete form and the results are not very reliable. In general the conclusions coincided satisfactorily with results of consideration of the preceding profile.

Along Teberda and Baksan rivers valleys restricted parts of profiles is obtained by special equipment TORTILLA what used a method of exchanging waves of earthquakes. These data results a description of Cis-Caucasian fault zone in western direction and moreover gives a materials to discuss on combined deep-seated structure of Caucasian central part and on particularities of Konrad and M- surfaces in Caucasian Mineral Waters region. Due to absence of seismic data the only gravimetric data were used for fitting of the Main Ridge zone profile. Minimum of gravity more than 100 mgl is probably connected with area of rocks undensified to 2.37 gr per cub.cm. It conceives to be in "granite" layer boundaries at 8-16 km that is centres zone of Elbrus volcano. It is possible an other interpretation of regional component of the gravity minimum. It could be influence of Benjoff zone, namely plunge of "basalt" layer into the mantle and development of young subvolcanic granite in upthrust part of the profile. The crust thickness is estimated here as 56 km mostly due to increase in thickness for the "basalt" layer. Along this profile the maximal thickness of "granite" layer is noted in junction zone of the North Caucasian monoclinale and Terek-Caspian basin. "Granite" layer is significantly discontinued here. In the region so-called Cav.Min.Waters-Nalchik zone of right lateral strike-slip is fixed. It is marked as area of disphase exchange waves in seismic data that is big time difference in the registration at the axis X and Y. The

maximal thickness of deposits cover, about 6 km, is manifested within Terek-Caspian foredeep.

It is necessary to note a fact that DSS research at the Caucasus are rather scarce and the results along the profiles are considered as reference one. To get square characteristics of separating surfaces (Moho or partial pre-Jurassic basement) gravity measurement data are used mainly. The anomalies of magnetic field are used essentially less. These data rests the M-surface has a unit trough for Caucasian orogeny and Post-Caucasian basins. As narrow depression it continues to the southern Caspian Sea. Minimal crust thickness is observed at the western Caucasus where it decreased to 35 km. For comparison: the observed crust thickness in Stavropol dome is 40-45 km.

At the Central Caucasus in the Elbrus volcano area it steeply increases up to 55 km. More densified profile network in Mineral Waters area results a complications in M- and Konrad -surfaces for this region. The area Ardon-Andijskoe Kojso is characterized by M-surface depth about 45-50 km. Farther to the East this depth steeply sinks to 55-60 km. Terek-Kuma depression has a regular thickness about 35-40 km.

With respect to the Konrad-surface no regular dependencies on correlation between its position and gravity field or local relief are not established.

Now we consider the upper part of cross-sections. At present all non-mountain territory of the northern Caucasus as well as aquatory of the Azov Sea and shale part of the Black Sea are investigated by seismic methods along rather dense network. So one can say the relief of pre-Jurassic basement of Cis-Caucasus is studied very attentively with exception of feredeeeps. The Greater Caucasus is a mountain area and seismic surveys here are almost absent. The bore-wholes are very rare. According gravity measurements it is impossible to construct the surface of pre-Jurassic basement for this area due to a faint differentiation of rocks on their physical features. That is typical in particular for the eastern Caucasus where any data of seismic and electromagnetic surveys about crust structure are not available. Moreover in Dagestan the complete disagreement in

structural plan of gravity and magnetic fields according the present tectonic maps is manifested.

Consider the analysis of data on Cis-Caucasian troughs.

- Folded basement of the West-Kuban foredeep is at 6-9 km in the eastern part and at 11-13 km in the western according to data of surveys and gravity anomalies calculations. The tectonics of Neogene structure is studied very well. The data on tectonics of Mesozoic and Low-Quaternary deposits are very scarce. In central part of the West-Kuban foredeep it is marked a significant disagreement between structural plan of lower part of deposits thickness and Upper-Quaternary. Several authors also note a disagreement in plans of Upper- and Low- M. structures. But these disagreements coincide with difference in plans of gravity and magnetic anomalies.

- Terek-Caspian foredeep is latitudinal asymmetric structure with a steep southern slope and a low-angle northern one according the geophysical data. Maximal deposits thickness is estimated as 8-10 km. Above Terek-Caspian foredeep it is observed an positive magnetic anomaly with several epicentres of 4 Me intensity. The origin is objects located in crystalline basement. The depth of the objects location is about 12 km and the estimation of magnetism is about 2000×10^{-6} cgs.

Now regard the data on the deep fault of the Greater Caucasus and Cis-Caucasus.

The Main Caucasian Thrust zone was studied by DSS, gravimetric surveys and geological investigations. At the depth of "basalt" and "granite" layer it has rather complicate structure. At day surface it presents locally readily mailable suture structure. The process of the thrust and relative uplift of the northern geoblock continues at present. That can explain vertical movements of the Main Ridge zone up to 12 mm per year and increased seismicity.

Many researchers mentioned the big role of anti-caucasian elements in construction of transverse zones at the background of total sublatitudinal extensions of the main tectonic units. These faults as a rule are covered and manifested by not always readily structural changes. Consider the Greater Caucasus

structure as edge of Eurasian Plate juncted with Arabian one, the slow decreasing of transverse dislocation amplitudes with distance from sutural zone can be understood. They appeared primarily in "granite" layer and provided different modern levels of elevated edge part of the northern geoblock. The thrust events in anti-caucasian interblocks faults have dependent meaning.

Preliminary of electromagnetic research of the profiles in the Northern Caucasus region show that the main feature here is again very well fixed a complex zone of Cis-Caucasian deep fault subparallel to the Main Caucasus Thrust one. This fault is the junction zone of folded basement of the Greater Caucasus and Scythian Plate which in geophysical data have no big differences and consider as front parts of the same Eurasian Plate. They are differ only by structure location. The Cis-Caucasian fault is readily mappable on geophysical data as upthrust of Stavropol dome to the crystalline basement located southward foredeep. To the depth of 7 km it is manifested in the direction north-east under angle about 65 degr. Farther eastward it is marked as Cav. Min. Waters-Nalchik right lateral strike-faults. Within Terek-Caspian foredeep between Andon and Andijsky transverse faults at the surface it is accompanied by Terek-Sunzhen domes. Farther to the east the Cis-Caucasian fault is accompanied by Khadum-Kukurtauss dome at the latitude of Makhachkala. Along the fault the increased gradients of magnetic and gravity field are fixed. The zone is characterized by low electrical resistances at the depth about 50 km. That is probably determine plots of partial melting of crust with well developed passing through surface structure of liquid phase. At the depth of 15-30 km a system of stratifying zones of increasing and decreasing resistance northward is observed. The development of local structures along the Cis-Caucasian thrust zone what appears in morphology of present surface, in neointrusion of Cav.Min.Waters and earthquake centres continues in present time. As a conclusion it is necessary to say that if the central part of The Caucasus is relatively studied then the eastern part is still a "blank" territory. Also the investigation of the

West-Kuban foredeep is necessary to connect with studies of aquatory of the Black Sea. The main improvement in our knowledge of the Caucasus we can expect from multidisciplinary researches what should include electric, seismic, gravity and space geodesy observations.

The first project used space geodesy technique namely GPS measurements, has been carried out in 1993 year in this area in framework of WEGENER program. That measurements be performed for studying the crustal deformations in the Northern Caucasus and relating these to Mean Sea Level at the Black Sea as it is defined in relationship to the geocentric positions of the satellite observation stations at Simeiz and Zelenchukskaya. Detailed preparations for such measurements employing the Global Positioning System (GPS) were made in the course of the 1991-1993 years. These included an extensive reconnaissance of the entire area from Crimea to Caspian via Caucasus in June/July 1992, field monumentation and control checks, point description and access clearance in May 1993, so that first observations could be made during the 5-day period June 29th to July 4th 1993.

At this time observations were performed simultaneously at 31 stations, (Fig. 3- sketch, Fig. 3-map) from Evpatoria to Uruk Valley, using receivers of identical type (Trimble-SSE) provided for the period by the Institut für Angewandte Geodäsie, Frankfurt/Main, Germany. The observations were made 24 hours per day.

In September 1994 the observations have been repeated. The observations were performed at 24 stations from Simeiz to Uruk valley. The observations were concentrated on the Caucasian part and the only two stations (Simeiz and Tuapse) on the Black Sea coast took part in observations in 1994y. Two new stations were added in the west part of the network to make it more homogenous. Also it was planned to establish two stations on the coast-line of Caspian Sea but unfortunately it was canceled due to cholera epidemic in Dagestan (Fig.4). For all stations the identical receivers (Trimble-SSE) have been provided by

IfAG. The observations were made 24 hours during period from 5, Sept. to 10, Sept.1994.

Up to date the preliminary processing and analysis of the 1993 measurement data is fulfilled. For GPS data-processing Berneese software 3.4, latest revision have been used. The obtained results are shown at Fig. 5-10. One can see rather high internal accuracy of the results.

VERTICAL ACCURACY

1. Ambiguity Fixing: Ambiguity Resolution improves

Accuracy of Coordinates by 10-20%

Ambiguity resolution improves scale-stability

Internal network accuracy not increased by fixing

Sample: baseline 6-m telescope- Zelenchukskaya(18 km)

standart deviation (X,Y,Z):

ambiguity fixed coordinate differences: 8.5/8.5/8.9 mm;

float coordinate differences: 5.5/11.7/9.8 mm

2. Local Troposphere: Signal delay caused by atmospheric water vapor (wet delay) is a major error source for height component. Sample results for a 50 km Baseline (Ware et al.1993) - Repeatability:

Pointing Water Vapor radiometer: + 2.6 mm

Water Vapor Radiometer (Zenith): + 5 mm

Hourly Estimates of Tropo-delay: + 5 mm(+bias)

Sample: baseline Gelenjik- Tuapse (96 km), Std.Dev:

No troposphere estimation (x,y,z): + - 25/20/32/ mm

2 Hour troposphere delay estimates: + - 15/7/28 mm

The obtained results establish a network of the first epoque for investigation of horizontal and vertical movements along the the main features in Caucasian section of the Eurasian-Arabian plate boundary.

At present the 1994 measurement data is processing.

The comparison of the both campaign results will allow to obtain the first estimation of the extent and magnitude of crustal motions in the region of the Northern Caucasus.

The future plans are : to include the results of absolute gravity measurements at the fiducial stations (Simeiz, Tuapse, Zelenchukskaya and Baksan) in the analysis, extension of profile to Caspian Sea, to provide SLR observations (mobile equipment) in Zelenchukskaya and to install permanent GPS receiver in Zelenchukskaya.

LITERATURE

1. Krapivner R.B., New conceptual model of folding tension.- Geotectonics, 1992, n 4, p.27-38
2. The general characteristics and development history of Caucas relief.- M., Nauka, 1977, 288pp
3. Tectonics of Mesozoic deposits of the Black sea basin.- M., Nedra, 1985, 216pp
4. Shempelev A.G., Deep expression of the Main Caucasian Overthrust.-Geotectonics, 1978, n 6, p. 57-65
5. Milanovsky, Y.Y., Khain V.Y. -Geology of the Caucasus, Edit. by Moscow University, 1973
6. Tvaltvadze G.K., Crustal structure in the Caucasus from the geophysical data.- Deep structure of the Caucasus, Nedra, 1966
7. Shempelev A.G. and Kumkova I.I., Outstripping movements of upper strata of geological section in the Northern Caucasus, EGS XIX Gen. Ass. Grenoble, 1994, Annales Geophysicae, v.12, Suppl. Part I, 1994, p.184
8. Shempelev A.G., Litovko G.V., Agamirzoev C.P. and Kumkova I.I., Deep structure of the Greater Caucasus and Cis-Caucasus from geophysical data.- EUROPROBE workshop, Essentuki, June 1994
9. Kumkova I.I., Shempelev A.G. Becker M., Marjanovic M. et al, Experiences with GPS measurements from Black Sea to the northern Caucasus.- EGS XIX Gen. Ass. Grenoble, April 1994, Annales Geophysicae v.12, Suppl. Part I, 1994, p. 183..
10. Kumkova I.I., Wilson P., Gurbanov A., Shempelev A., An investigation of ongoing deformation in the Northern Caucasus.- EGS. XVIII Gen Ass. Weisbaden, May 1993, Annales Geophysicae v.11, Suppl. Part I, 1993, p. 65.
11. Wilson P., Kumkova I., Olifirov V. et al, Experiences with GPS measurements from the Black sea to the northern Caucasus in the framework of the objectives of SELF and WEGENER,- WEEGENER meeting, 20-26 June 1994, St.Petersburg, in press

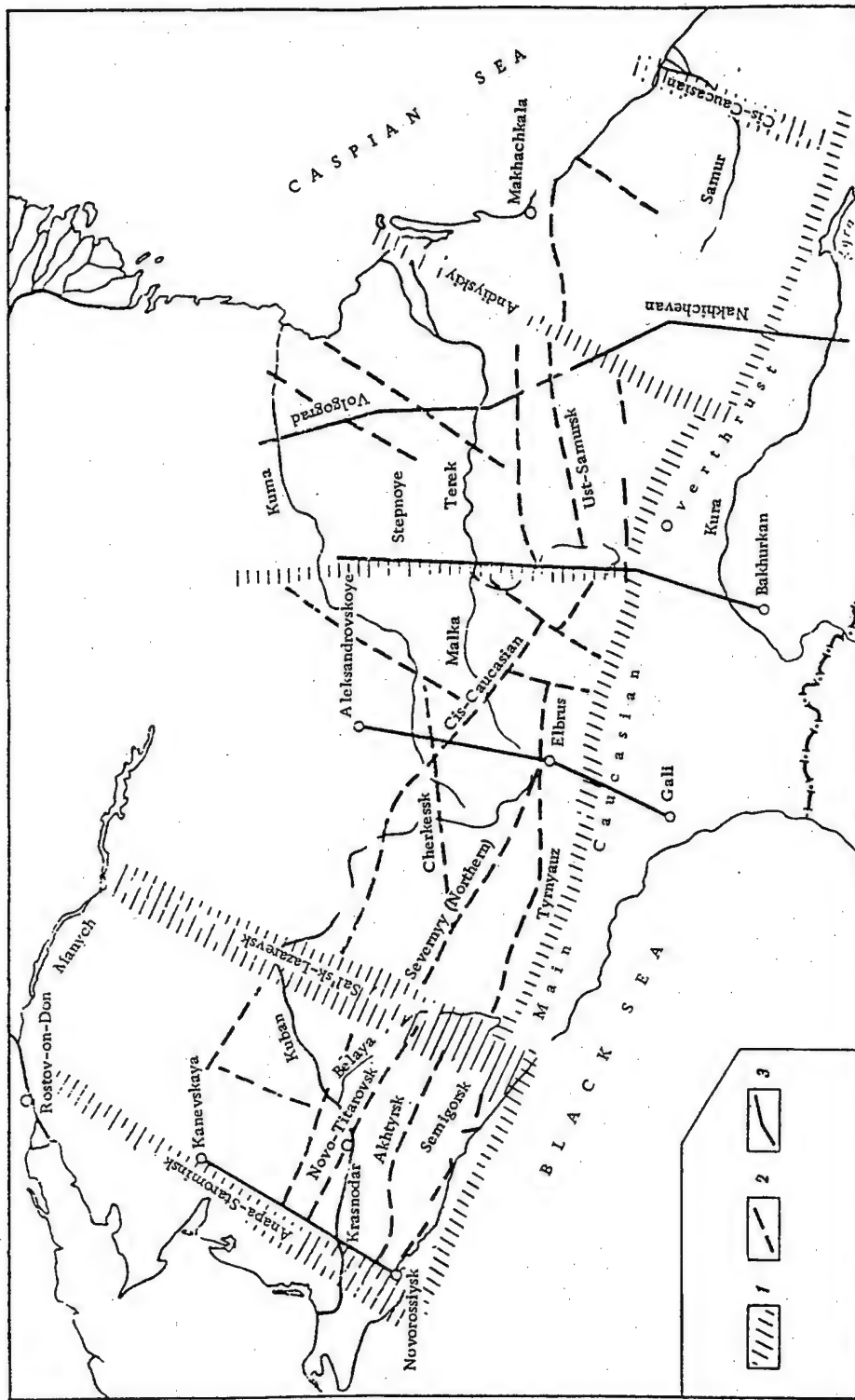


Fig. 1. Principal faults of the Greater Caucasus and Cis-Caucasus:

1) probable deep faults; 2) other faults identified by various methods; 3) lines of geological and geophysical profiles.

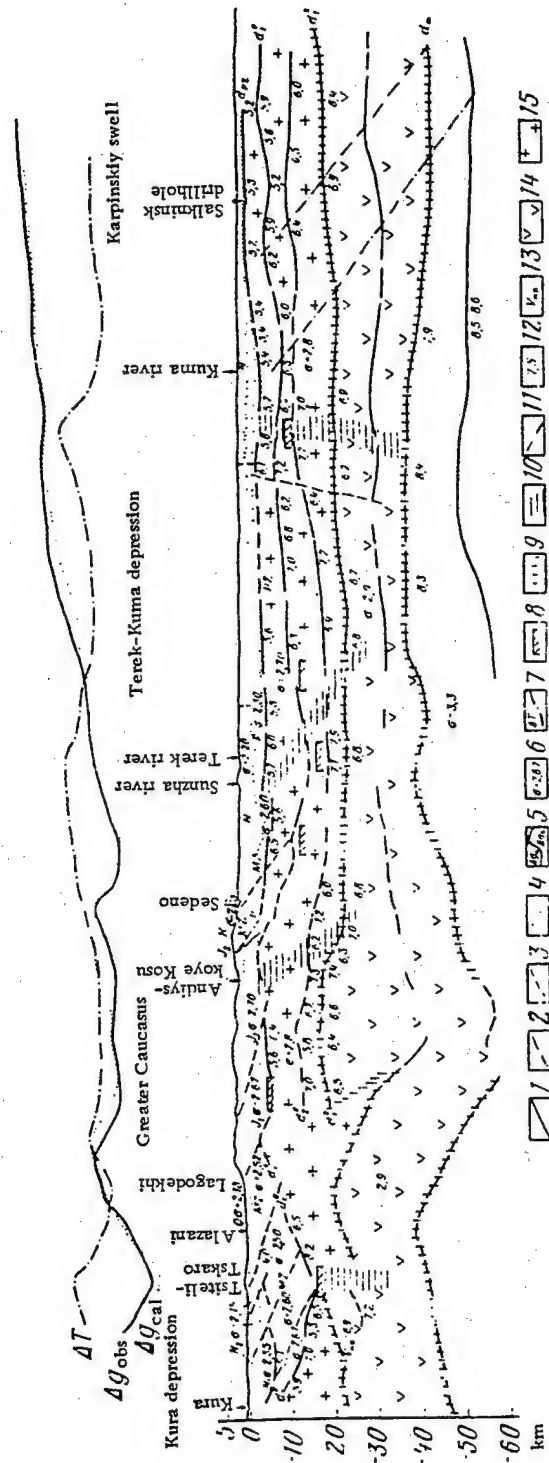
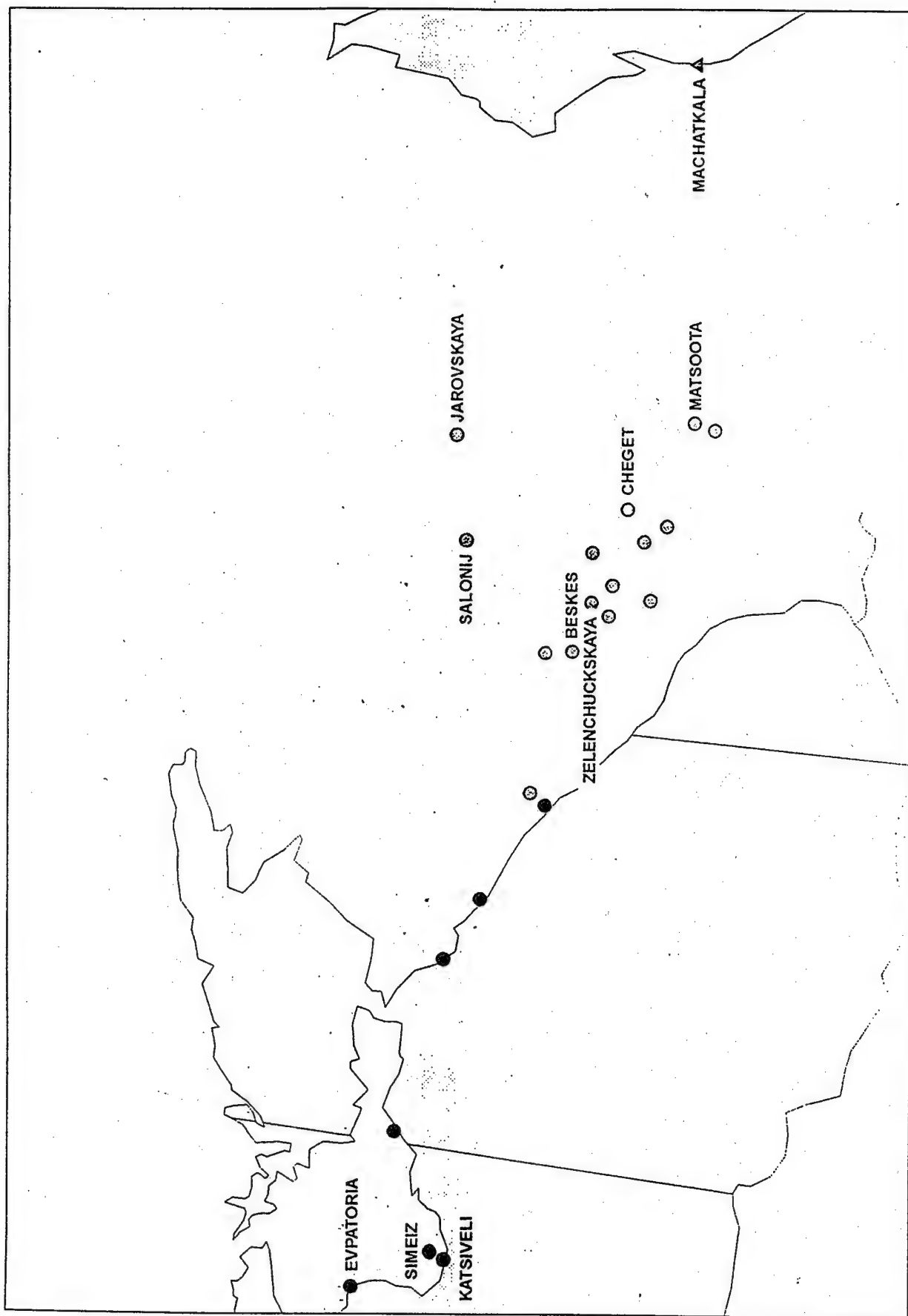


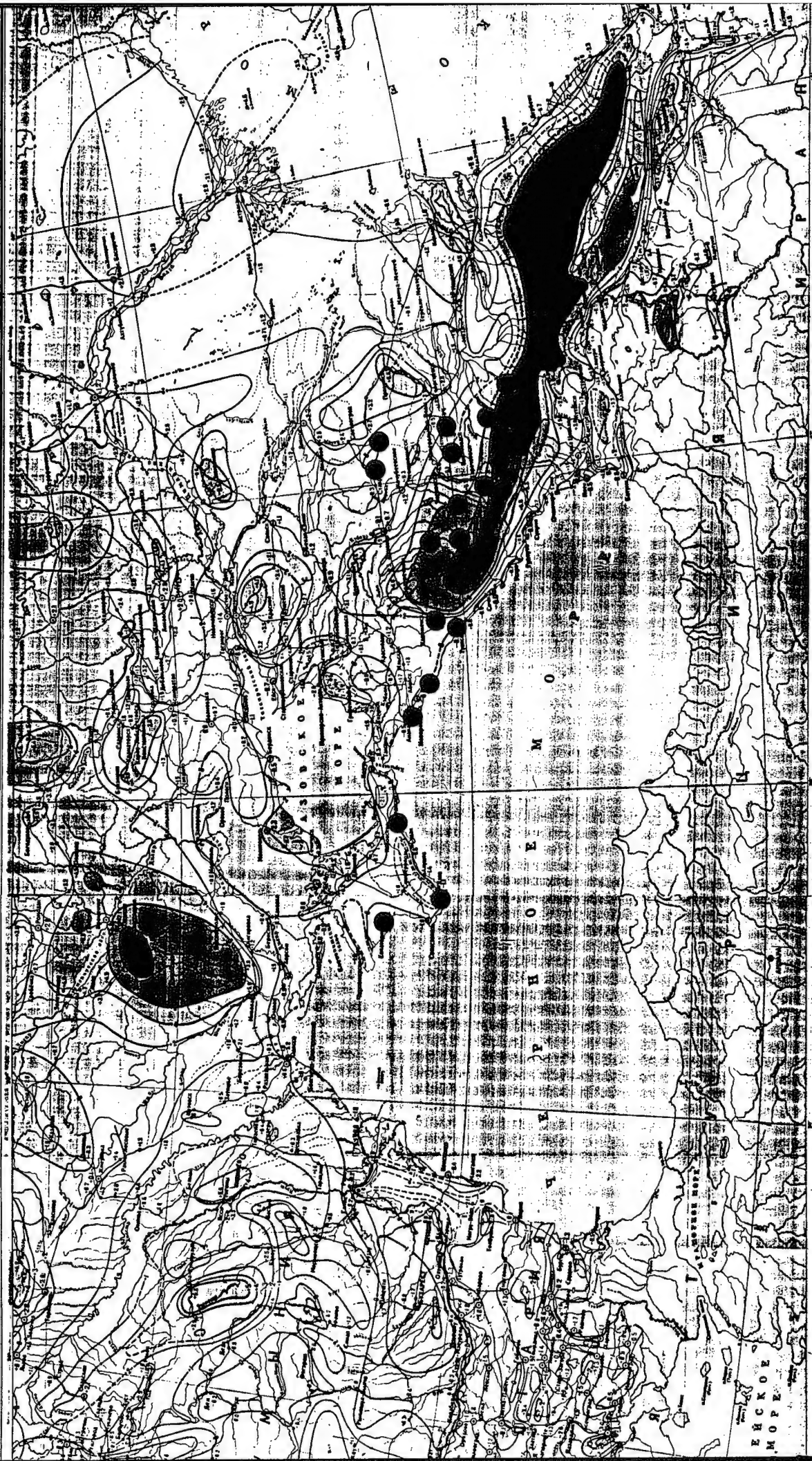
Fig. 2. Geological and geophysical cross section of the crust, with gravimagnetic data from the Volgograd-Nakhichevan profile:

- 1) boundaries drawn from reliable GSS data; 2) probable boundaries; 3) probable faults observed at the surface; 4) discontinuity boundaries in Mesozoic and Cenozoic deposits; 5) observed Δg_{obs} and calculated Δg_{cal} gravity anomalies; 6) rock density, g/cm³; 7) curve of magnetic field ΔT ;
- 8) upper boundaries of magnetic bodies; 9) upper and lower surfaces of the "basalt" layer; 10) probable deep fault zones; 11) axes of uplifts and downwarps; 12) boundary velocities, km/sec; 13) interlayer velocities, km/sec; 14) "basalt" layer; 15) "granite" layer.



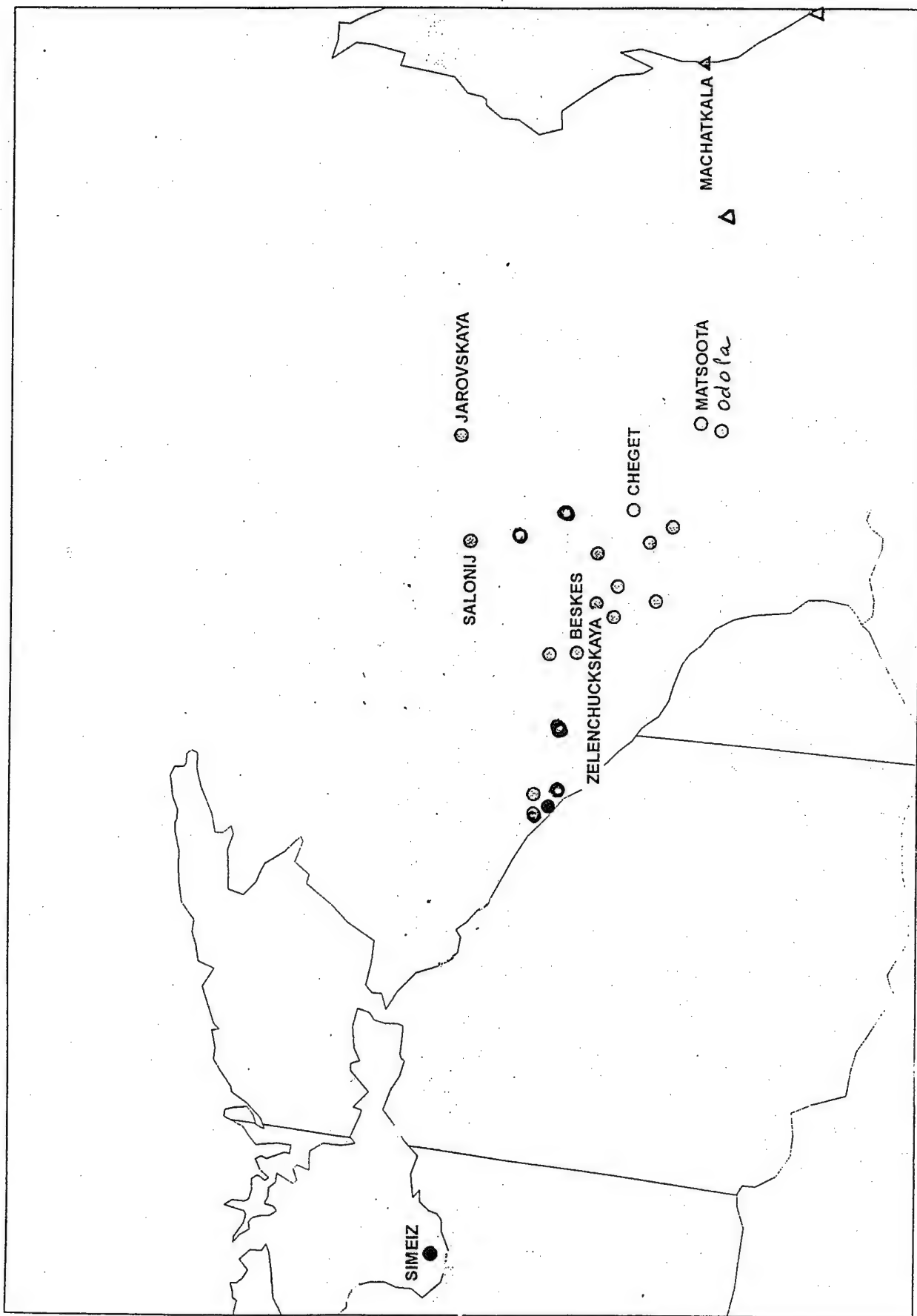
PEKA 93 (29.06. - 03.07.1993) ● Tide Gauges + GPS ○ GPS Δ planned

Лист 5 МАРТА СОВРЕМЕННЫХ РЕЛЬЕФНЫХ ДАННЫХ СЕВЕРНОЙ ЧАСТИ ВОСТОЧНОЙ ЕВРОПЫ 1:2 500 000



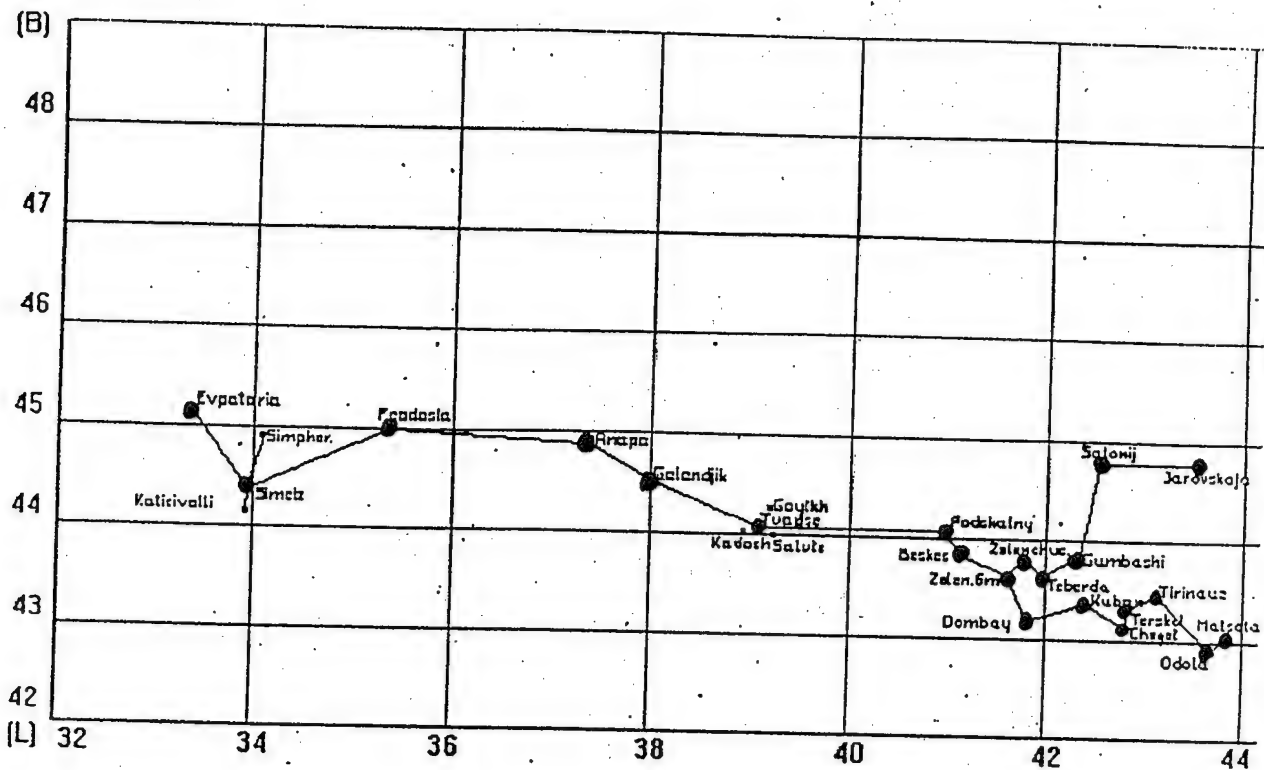
МАСШТАБ 1:2 500 000

Fig. 3

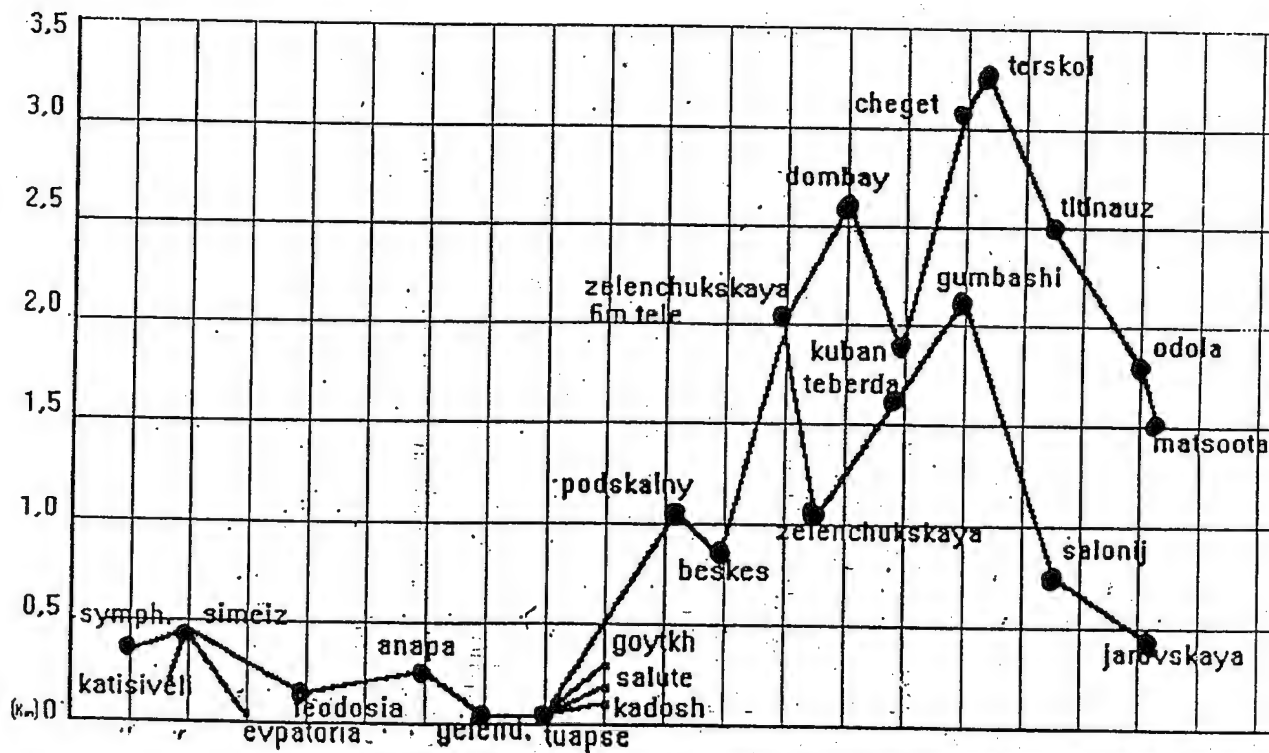


PEKA-94 (5-10.09.1994)

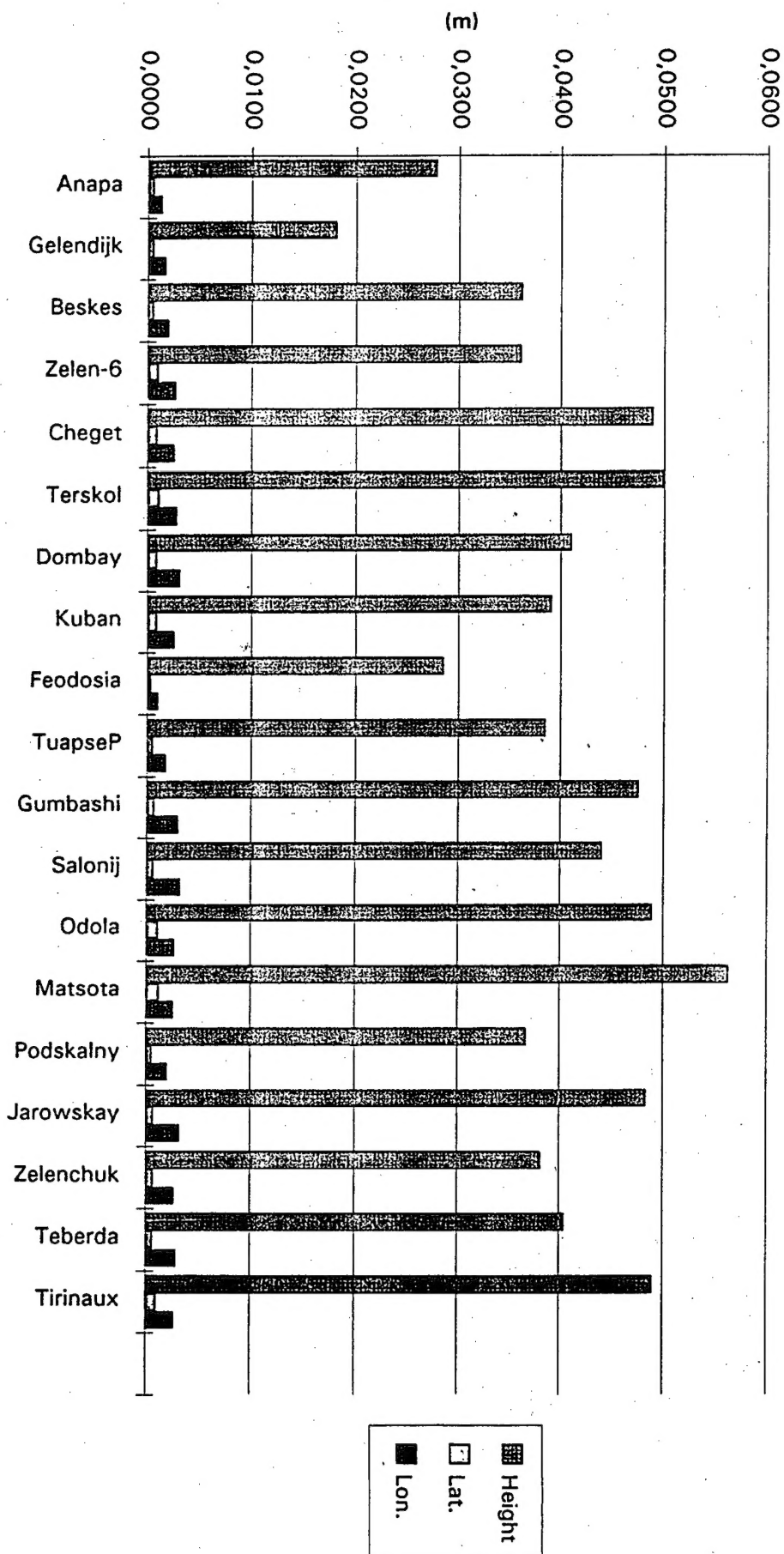
● Tide Gauges + GPS ○ GPS △ planned



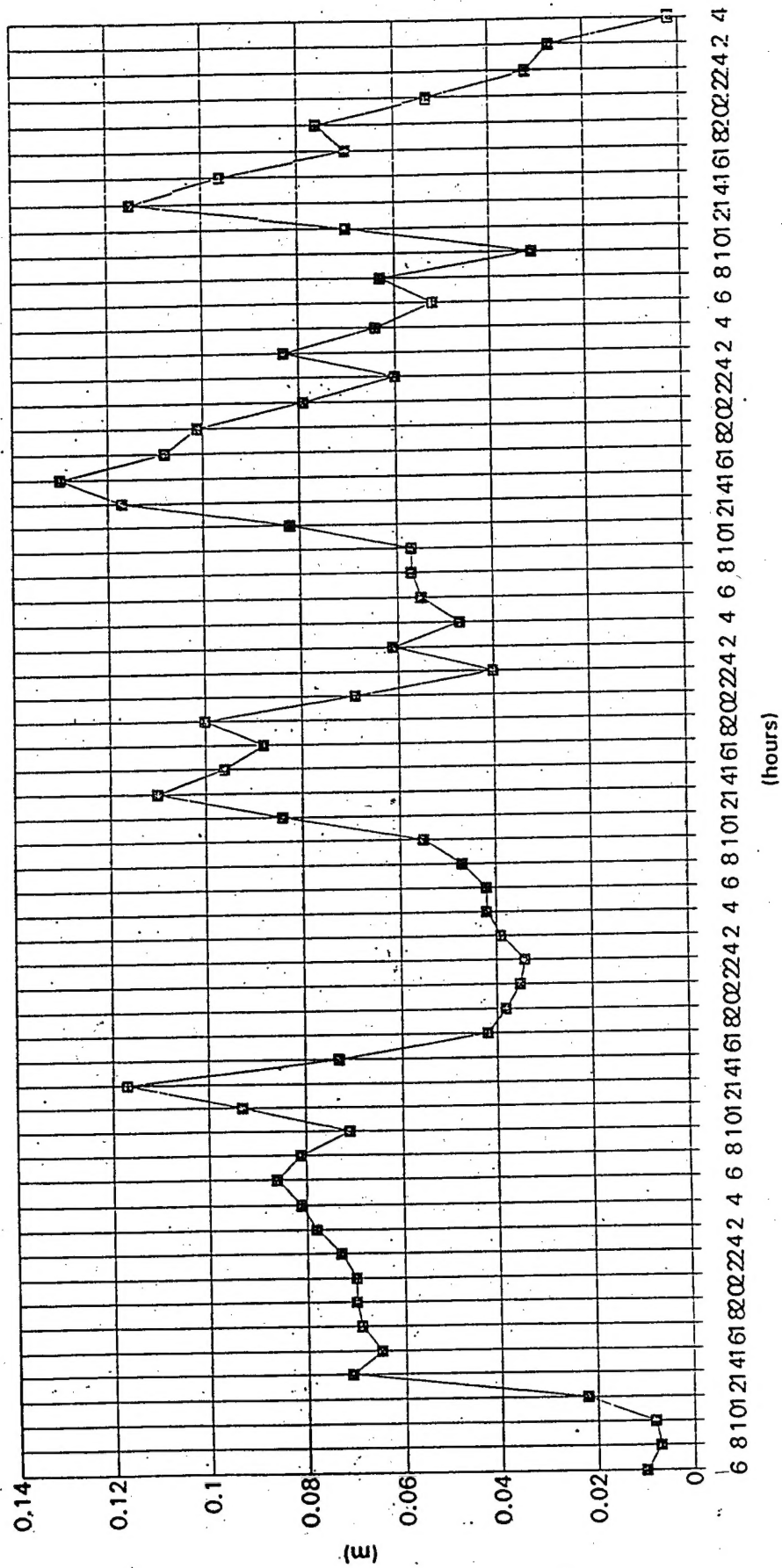
PEKA 93 Vertical profile of baselines.



Single Days Standard Deviation



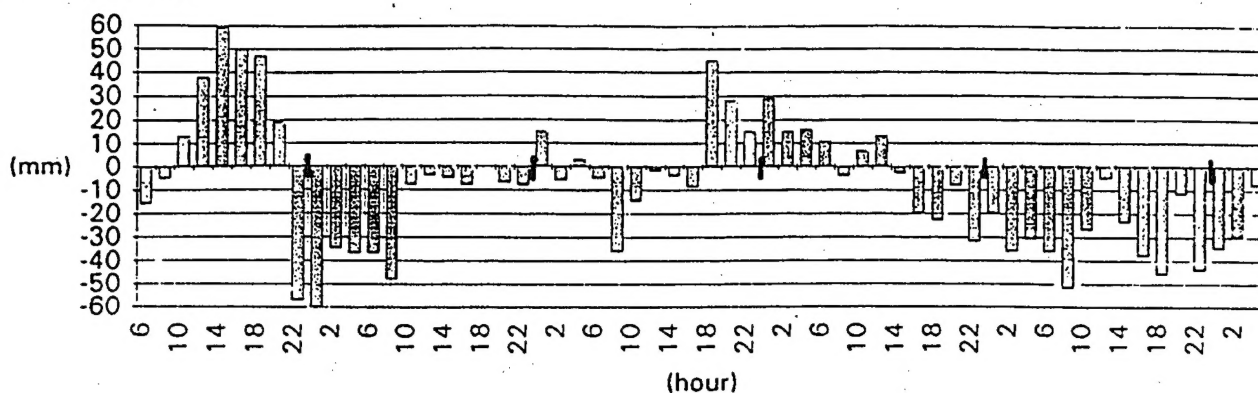
Estimated Tropospheric Zenith Delay Simaez - Zele6m - FinFlo



$\Delta H = 28m$

Differences between troposphere corrections, Anapa(50 m)-Tuapse
Pegel(22 m)

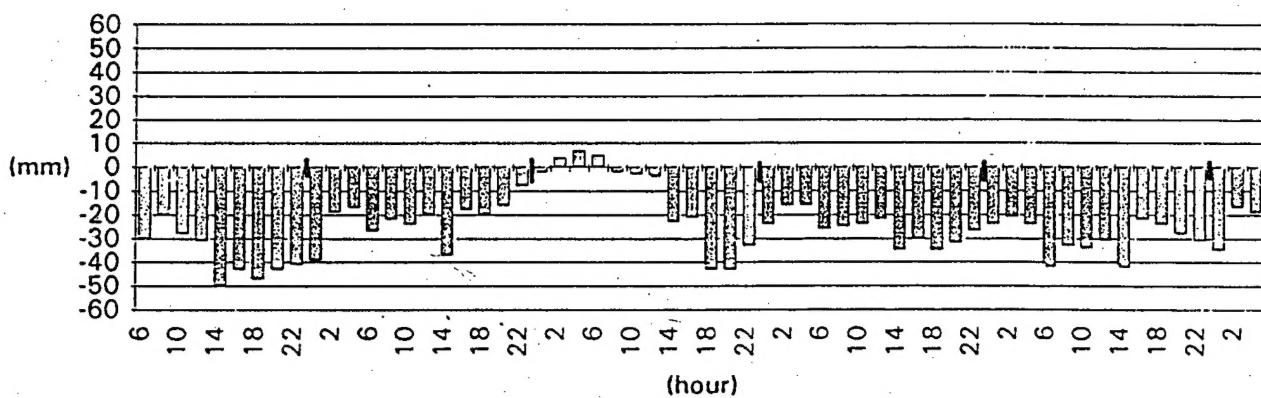
$\Delta s \approx 200km$



$\Delta H = 1555m$

Differences between troposphere corrections, Gumbashi(2224 m)-
Salonij(669 m)

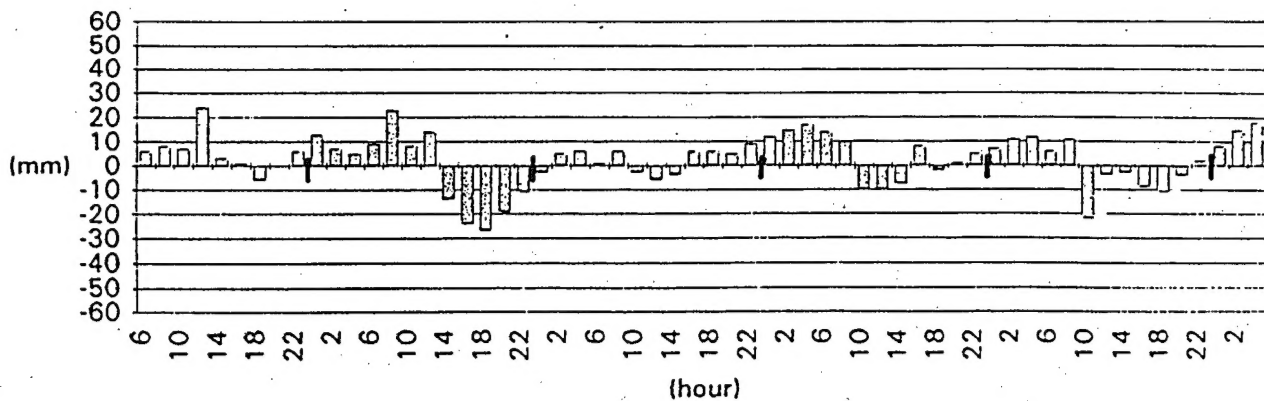
$\Delta s \approx 100 km$



$\Delta H = 19m$

Differences between troposphere corrections, Podskalny(1176 m)-
Zelenchuiskaya(1157 m)

$\Delta s \approx 50km$



PEKA93-Single Days versus 5-Day Solution

Standard Deviations in meter

Day	X	Y	Z	height	latitude	longitude
180	0,2406	4,8424	9,8059	7,1303	5,517734	54,0022
181	0,2162	4,8565	9,7486	7,0827	5,516651	54,0034
182	0,2219	4,8828	9,7793	7,1190	5,516890	54,0042
183	0,2842	4,8145	9,7739	7,1201	5,516607	54,0001
184	0,2567	4,8260	9,7796	7,1138	5,517068	54,0012
all 0"	0,2411	4,8525	9,7739	27,1127	5,516847	54,0026

Gelendjik Std.Dev 0.018 0.001 0.002

Day	X	Y	Z	height	latitude	longitude
180	6,2371	4,5184	8,3504	3,4196	28,7460	2,2268
181	6,2527	4,5250	8,2706	3,3765	28,7438	2,2265
182	6,2000	4,5414	8,3278	3,3955	28,7458	2,2286
183	6,3731	4,4671	8,3928	3,4965	28,7456	2,2210
184	6,2689	4,5172	8,3961	3,4674	28,7466	2,2258
all 0"	6,2400	4,5612	8,3471	3,4399	28,7453	2,2281

Terskol Std.Dev. 0.050 0.001 0.003

Day	X	Y	Z	height	latitude	longitude
180	9,3222	2,9532	3,4453	2,5900	27,9716	36,9155
181	9,3508	2,9710	3,4244	2,5994	27,9704	36,9153
182	9,3598	3,0109	3,4751	2,6578	27,9709	36,9164
183	9,4369	2,9479	3,4842	2,6785	27,9706	36,9121
184	9,3948	2,9527	3,4740	2,6501	27,9711	36,9134
all 0"	9,3682	2,9754	3,4558	2,6330	27,9708	36,9150

Tuapse Pegel Std.Dev. 0,039 0,000 0,002

Day	X	Y	Z	height	latitude	longitude
180	8,2941	8,1069	1,1828	7,2837	12,0110	42,8275
181	8,3367	8,1297	1,1596	7,3015	12,0094	42,8269
182	8,2755	8,1377	1,1711	7,2803	12,0106	42,8290
183	8,4296	8,0639	1,2296	7,3686	12,0104	42,8220
184	8,3531	8,0996	1,2220	7,3392	12,0110	42,8255
all 0"	8,3109	8,1361	1,1897	7,3115	12,0104	42,8279

Zelenchukskaja Std.Dev. ,038 ,001 ,003